DOCUMENT RESUME

ED 363 263 IR 016 171

AUTHOR	Spector, J. Michael; And Others
TITLE	An Automated Approach to Instructional Design Guidance.
PUB DATE	Apr 93
NOTE	11p.; Paper presented at the Annual Meeting of the American Educational Research Association (Atlanta, GA, April 12-16, 1993).
PUB TYPE	Reports - Descriptive (141) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Artificial Intelligence; Authoring Aids (Programing); Automation; *Computer Assisted Instruction; *Computer Software Development; *Courseware; *Expert Systems; *Instructional Design; *Military Training; Online Systems
IDENTIFIERS	Air Force Human Resources Laboratory; IDD Advisor; *Instructional Systems Development; Interactive Systems

ABSTRACT

This paper describes the Guided Approach to Instructional Design Advising (GAIDA), an automated instructional design tool that incorporates techniques of artificial intelligence. GAIDA was developed by the U.S. Air Force Armstrong Laboratory to facilitate the planning and production of interactive courseware and computer-based training materials. The tool is a case-based system that incorporates a short exposition of Gagne's nine events of instruction and four complete examples of applying the nine events to identification of naval insignia, classifications of electronic resistors, checklist procedure for the F-16 Gatling gun, and procedure for testing a patient's respiratory capacity using a spirometer. The paper covers (1) the issues involved in developing an automated instructional design advisor; (2) the results of Gagne's evaluation of the initial GAIDA case (the checklist for the F-16 gun); (3) a description of how GAIDA has been redesigned; and (4) how GAIDA will be used in future instructional design research and development projects. (Contains 18 references.) (KRN)

AN AUTOMATED APPROACH TO INSTRUCTIONAL DESIGN GUIDANCE

J. Michael Spector
Daniel J. Muraida

Air Force Armstrong Laboratory, Human Resources Directorate
AL/HRTC, Brooks AFB, TX 78235-5601

&

Tricia Jones

University of Michigan, School of Education
Ann Arbor, MI 48109-1259

Paper presentation for the 1993 Annual Meeting of the American Educational Research Association, Atlanta, GA (Instructional Technology Special Interest Group), 15 April, 1993.

The opinions expressed herein are those of the authors and do not necessarily reflect the views of the United States Air Force or the University of Michigan.

Keywords: case-based reasoning, computer-based training (CBT), instructional design, interactive courseware (ICW).

ABSTRACT

Interactive courseware (ICW) and computer-based training (CBT) development are growing in demand as well as in complexity. Departments of instructional technology are simply unable to keep up with the demand. The situation is most severe in the Department of Defense (DoD) where declining training budgets restrict how much can be spent on contracted efforts (typically costly) and where a declining number of military training specialists force the DoD to consider alternative means of achieving the development of more cost effective ICW/CBT using primarily in-house expertise. The solution is to provide automated systems to support the development of ICW and CBT. One promising technology in this area is to incorporate the techniques of artificial intelligence in automated tools for instructional design. This paper describes the rationale of one such system, the Guided Approach to Instructional Design Advising or GAIDA, which probably represents the low end of the scale in artificial intelligence training support systems.

SUMMARY

The Air Force Armstrong Laboratory is exploring automated means for assisting instructional designers in the planning and production of computer-based technical training materials (interactive courseware, ICW). The motivation for this effort is twofold: (1) increasing demands for computer-based (CBT) training materials, and (2) limited computer-based instructional design expertise. Our major research and development effort in this domain is called the Advanced Instructional Design Advisor (AIDA) (Muraida & Spector, 1990). AIDA represents a systematic attempt to encapsulate established instructional strategy frameworks appropriate to a selected but substantial subset of instructional objectives and to make them available to subject-matter experts for content input. The AIDA effort has produced two interesting instructional design tools. The first tool focuses on objective-specific design expertise and incorporates expert system technology in the form of rules for configuring specific instructional interactions. The second tool incorporates case-based reasoning methodologies and provides completely worked examples of four technical training modules representing a variety of training situations.

The first tool (XAIDA or Experimental Advanced Instructional Design Advisor) uses object-oriented instructional frameworks that represent an implementation of second generation instructional design and the four associated transaction shells (Merrill, Li, & Jones, 1990). XAIDA is currently undergoing formative evaluation at a field site. The next phase of research for XAIDA will include systematically varying instructional parameters in order to develop empirically proven instructional tactics. For example, a transaction can be configured so as to provide by default a given amount and type of performance feedback at a given point in a particular type of lesson. Lessons can then be quickly developed, delivered to students, and evaluated with regard to effectiveness. This capability will allow data to be collected to determine optimal instructional tactics, given a particular type of instructional objective and overall strategy.

The second tool (GAIDA or Guided Approach to Instructional Design Advising) is based explicitly on Gagné's nine events of instruction (1985) and is the focus of this paper. GAIDA is a case-based system that incorporates a short exposition of the nine events of instruction, as well as four complete examples of applying the nine events to identification of naval insignia, classification of electronic resistors, checklist procedure for the F-16 gatling gun, and procedure for testing a patient's respiratory capacity using a spirometer. The examples can be displayed from two perspectives: (1) instructional designer, and (2) student. In student mode GAIDA allows the user to select one of these four lessons and then presents a computer-based training session including performance measures. When in instructional designer mode GAIDA allows the user to select a lesson and view specific design guidance (an elaboration of the nine events appropriate for that type of lesson objective) along with an abbreviated representation of the actual lesson. The designer can jump to student mode at any point in the elaboration to get a closer view of the lesson.

OBJECTIVES

This paper will include a discussion of the research program in automating instructional design that resulted in the GAIDA software. Specific purposes include the following:

(1) Discuss the issues involved in developing an automated instructional design advisor, focusing on offering online guidance for courseware development;

(2) Report the results of Gagné's evaluation of his initial GAIDA case, the checklist procedure for the F-16 gun (Gagné, 1992);

(3) Describe how GAIDA has been redesigned and demonstrate all four cases; and

(4) Indicate how GAIDA will be used in future instructional design research and development projects.

BACKGROUND

Instructional Systems Development (ISD)

Most ISD models are based on an engineering approach to curriculum and lesson development (Andrews & Goodson, 1980). These models typically divide the ISD process into five stages or phases: (1) analysis, (2) design, (3) production, (4) implementation, and (5) maintenance (Golas & Shriver, 1991). Associated with each phase are specific goals and subtasks. For example, the design phase is concerned with specifying instructional objectives, grouping and sequencing those objectives, and identifying appropriate instructional treatments.

Older ISD models often fail to account for relevant cognitive aspects of the learning task (Tennyson, 1991). For example, a behaviorally oriented ISD model might suggest that the grouping and sequencing of instructional objectives should always reflect the specific sequences of tasks actually performed on the job. While this is certainly true in some cases, there are cases when a cognitively oriented ISD model would suggest that it is more effective in promoting recall, retention. and transfer to group and sequence objectives around relevant mental models. In addition, older ISD models have suggested that the activities in each phase are sequential and that evaluation comes toward the end of the process. A recent study of expert instructional designers indicates that they seldom perform the idealized activities of an ISD model in a sequential manner (Rowland, 1992). Moreover, it is appropriate to include evaluation (quality control and both formative and summative evaluation) into each phase and subtask of the model (Tennyson, 1991).

The value of an ISD model is not that it prescribes a definite set of activities to be performed in a definite order so as to accomplish an effective instructional development. The real value of an ISD model is that it provides a meaningful organizing framework within which development activities can be described, discussed, and possibly actualized. In other words, an ISD model is a kind of mental model for instructional development, and it should be regarded as such, rather than as a rigid set of task prescriptions. In any event, for the purposes of this paper, the ISD model sketched above will provide a framework for the applicability of various AI techniques.

Courseware Design

With the advent of affordable personal computers and increasing capabilities to support multimedia, the process of developing instruction targeted for delivery by computers (courseware) has caused ISD models to accommodate the special requirements of CBT and ICW. For example, continuing interaction with programming and systems specialists is now planned for most serious courseware development efforts.

However, it is widely recognized that there is a shortage of well-trained and experienced ICW developers (Spector, Muraida, & Dallman, 1990). In addition, there exists incomplete knowledge concerning how to optimize various media in support of specific learning objectives (Friedman, Polson, & Spector, 1991). However, it is also commonly acknowledged that careful planning is essential for the successful development of courseware. Unlike instruction to be delivered by humans, ICW must be robust and capable of being made adaptable or generalizable across a variety of students and settings. Efforts to develop ISD models and standards specifically for ICW are now commonplace, both in the military as well as in industry (e.g., see MIL-STD-1379D, Appendix B, Systems Approach to the Interactive Courseware Development Process).

Technical Training in the Department of Defense (DoD)

The shortage of ICW experts is particularly acute in the DoD. Typically, the military instructional designer is a subject-matter expert (SME) who has completed a brief course on designing instruction (Spector *et al.*, 1990). For example, the technical training specialist may be a non-commissioned officer with a great deal of experience with a particular piece of equipment but with very little background in educational psychology or instructional technology.

With declining training budgets and personnel cutbacks it appears unlikely that the DoD will be able to accomplish all of its technical training ICW requirements through outside contracts. However, there will continue to be requirements for effective technical training in the military. In fact, given the impetus towards a smaller but more flexible force structure using highly complex weaponry, it is most likely that technical training requirements will remain critical. In order to satisfy these requirements, there will be a demand for increasing use of ICW and for increasingly effective ICW. As a consequence, DoD laboratories have been exploring ways to provide the required ICW expertise to the SMEs responsible for the development of much of DoD courseware. As the center of excellence for artificial intelligence (AI) in training, Armstrong Laboratory is especially interested in applying AI techniques to the design of effective ICW.

Artificial Intelligence & Training

In order to complete the context for the system described below, it is necessary to provide a working definition of AI. There are, of course, many definitions in the AI literature. Some emphasize the psychological aspects of human intelligence and various methods of modeling human intelligence. Others emphasize the mathematical complexity of certain problems addressed by AI researchers. A more neutral approach is taken by Rich and Knight who define AI to be "the study of how to make computers do things which, at the moment, people do better" (1991, p. 3). It is not clear what benefit is to be derived from the endless debates concerning whether particular machines and systems exhibit intelligence. So as to avoid those debates, I shall adopt Gagné's suggestion that AI be regarded simply as engineered cognition (Spector, Gagné, Muraida, & Dimitroff, 1992).

The most prevalent AI architectures are expert systems and artificial neural networks. To date there has been very little work in applying artificial neural network technology to training systems. The most obvious application for neural networks is in delivery systems involving speech recognition and/or generation, but there has been very little development of such systems for training purposes. As a consequence, the most used AI technology in training is the expert system, especially those using planning architectures.

Expert Systems

For the sake of this discussion, an expert system is an AI system which consists of a rule base, an inference engine, a database, and an interface with a user. The rule base is usually represented in the form of IF-THEN statements and is taken to represent the knowledge of an expert in the subject. The inference engine provides a mechanism to examine the current status of the system, search the rule base, find any and all applicable rules, select an appropriate rule to apply, and then apply the rule, thereby creating a new system status. It should be obvious that there is nothing magical or mysterious about expert systems. They do, however, represent a very powerful problem solving technique.

Expert systems are normally characterized as either planning systems or as diagnostic systems. Planning systems work forward from a given system state toward a final state. For example, a planning system could take input regarding lesson objectives and subject matter and develop a lesson outline, a lesson plan, and possibly even a prototype lesson. On the other hand, diagnostic systems work backward from a given system state toward a cause or analysis. For example, a diagnostic system could take a given ICW lesson and student performance data as input and provide an explanation why certain parts of the lesson were not working well. There have been no diagnostic expert systems developed and tested for the domain of instructional design, although Duchastel has recommended that this is a possibility worth exploring (1990).

Planning Architectures

There have been a number of attempts to develop expert planning systems to support various aspects of the ISD process. Most notable among these efforts is Merrill's ID Expert (Merrill, Li, & Jones, 1990), which provided the core technology (transaction theory) for AIDA. The original motivation behind ID Expert was to develop a rule base of instructional prescriptions and to use those rules to generate appropriate frameworks for lesson materials which would be provided by an SME. Other applications of expert planning systems to various ISD processes are possible.

Table 1 provides an organizing framework for the various ways that AI has been incorporated into the ISD process. The Guided Approach to Instructional Design Advising (GAIDA) is based explicitly on Gagné's nine events of instruction (Gagné, 1985).

Table 1

AI Techniques & ISD

I. Analysis Training Requirements Tools Cognitive Task Analysis Decision Support Systems	II. Design Instructional Design Advisors Online Examples & Guidelines Case-based Systems Rule-based Systems Intelligent Tutors & & Critiquers
III. Production Intelligent Development Tools Graphics Mini-advisors Audio, Video, and Interface Tools Intelligent Lesson Templates (e.g., XAIDA)	IV. Implementation Adaptive Delivery Intelligent Tutors Adaptive Testing
V. Maintenance Monitoring/Diagnostic Tools	

These examples of applicable AI techniques in the ISD domain are not meant to be exhaustive. What is offered here is a way to classify various efforts to develop intelligent instructional systems. It is worth noticing that no examples of intelligent applications in the maintenance phase are identified, although it is possible to imagine an automated instructional system that monitored either the instructional development process or the progress of learners using the system, processed the results, and filtered those results through a set of rules which prescribed variations on the development or delivery process.

For example, a system could record and analyze answers to questions. If a particular question was never answered correctly, the system might recommend a remedy for the situation. A system might also monitor where learners spent most of their time with the system and analyze how that time contributed to learning outcomes. If it appeared that time was wasted in one part of the system, then the system might recommend some kind of remedy for that situation.

There is nothing in this framework to prevent a particular system from being categorized in more than one area. In fact, we view XAIDA as an intelligent application in the middle three phases of ISD, although our research interests are clearly focused on the design phase.

Approaches to Automating Instructional Design (ID)

As already mentioned the two projects mentioned here focus on the application of AI to the instructional design phase. It is worth noting that GAIDA and XAIDA represent only two of a number of possible approaches to intelligent instructional design. Tennyson has proposed the more ambitious approach of building an intelligent tutoring system (ITS) for the domain of instructional design (1991). Duchastel has proposed an expert critiquing system which can evaluate designs created by relatively experienced instructional designers (1990). It is probably premature to proceed with such ambitious efforts, however. Indeed, the validated results of efforts like GAIDA and XAIDA will form an essential part of an expert ISD critiquer or an ITS for ID.

THEORETICAL FRAMEWORK FOR GAIDA

Applications for Courseware Design

Online Guidance

The most direct method of capturing instructional design expertise and providing it to novice designers is to construct an expert tutorial on instructional design and to connect it to various steps in the development process. This is the basic idea behind the ID Advisor (idEa) developed by Progressive Learning Systems and Ford Aerospace's TIPS (The Instructional Prescription System). Because novice designers may desire the rigors of a short course or tutorial in the course of their experiences, providing such guidance online and in the context of their design efforts appears highly desirable and is included in the development plan for XAIDA.

Elaborated Examples

A case-based approach to instructional design most closely approximates what expert designers actually do (Rowland, 1992). GAIDA uses this approach to provide four completely worked examples of applying Gagné's nine events of instruction to technical training lessons in a CBT environment. The four examples involve an identification task, a classification task, a checklist procedure, and a memory procedure. Subject material ranges from identifying naval insignia, classifying resistors, checking the operation of the F-16 gatling gun, and interpreting the results of a medical procedure.

Design Implications for GAIDA

Three components comprise the theoretical framework for GAIDA: (1) different learning objectives require different instructional strategies (Gagné, 1992), (2) instruction consists of a set of events (usually nine) external to the learner which are designed to support the internal processes of learning, and (3) elaboration of these events varies with the learning objective (verbal knowledge, concepts, procedural rules, motor skills, and attitudes) and with the learning environment (determined by both delivery and learner capabilities).

METHODOLOGY IN DEVELOPING GAIDA

GAIDA is coded in ToolBook 1.5, a hypermedia authoring tool that runs under Windows 3.0 on Intel 80386/80486 personal computers. Professor Gagné provided system specifications as part of his work at the Armstrong Laboratory as a National Research Fellow. The programming has been accomplished by graduate students and by Armstrong Laboratory programmers.

GAIDA was originally conceived as an alternative to the XAIDA system (Gagné, Tennyson, & Gettman, 1991). GAIDA is designed to leave detailed implementation of the instructional design to the user. In contrast, XAIDA is designed to relieve the user of as much instructional design decision making as possible. A comparative analysis of GAIDA and XAIDA is planned next year after both systems have been revised and retested in accordance with their respective formative evaluations.

Gagné's formative evaluation was conducted at the Lowry Air Force Base Technical Training Center (1992). Six subjects participated in the study. Each subject was acquainted with the subject matter; five were novice instructional designers; one was generally familiar with instructional design. Subjects were presented with the GAIDA software which described how to apply the nine events of instruction to teach the procedure for a ground check of the F-16 gun. Subjects were asked to follow the design guidance being suggested by the software and create a paper-based version of a similar lesson. Subjects kept detailed notebooks on their reactions and were asked to think aloud at key points concerning three criteria: clarity, impact, and feasibility. Results of this evaluation were quite favorable (Gagné, 1992). Subjects generally found the design guidance understandable, meaningful, and useful.

The experienced designer took exception with the stated purpose of the lesson and argued that what students needed to be taught was more system knowledge. This finding is consistent with Rowland's finding that experienced designers spent much of their initial lesson planning critically examining the stated purpose of the instruction (1992). Rowland also noticed that experienced designers apparently worked from the perspective of similar cases. This finding suggests that the GAIDA approach of providing less experienced designers with worked cases annotated with a detailed instructional design commentary is likely to enhance the quality of CBT produced by novice designers.

CONCLUSIONS

GAIDA's Utility

GAIDA has now been tested by more than a dozen novice designers, all of whom have found it to provide useful and meaningful instructional design guidance. As a consequence, it is being provided to users as an interim product to supplement the instructional design training provided by the Air Force. GAIDA is extensible in the sense that users can add their own best cases by adhering to a few ToolBook conventions when creating the sample lesson.

Unresolved Issues

There is much that we do not know concerning how individuals learn, and, as a consequence, how to support learning processes. There is reason to expect that collaborative learning will be highly effective in certain computer-based environments (Stephenson, 1991). We also expect to find that auditory presentations will be highly effective in particular learning situations (Spector & Muraida, 1991). However, the specifics concerning these and other factors relevant to the design of a more intelligent advisor for ICW design await further empirical research.

Having established the utility of GAIDA in the domain of instructional design advising for novice ICW developers, we are now in a position to use GAIDA and the associated data as a baseline of comparison to how useful more sophisticated instructional designer advising systems are (e.g., when we evaluate XAIDA we can easily create treatment groups which receive GAIDA advising in addition to or in place of XAIDA's intelligent framework).

REFERENCES

Andrews, D. H. & Goodson, L. A. (1980). A comparative analysis of models of instructional design. *Journal of Instructional Development*, 3(4), 2-16.

Duchastel, P. C. (1990). Cognitive designs for instructional design. *Instructional Science*, 19(6) 437-444.

Friedman, A., Polson, M. C., & Spector, J. M. (1991). *Designing an advanced instructional design advisor: Incorporating visual materials and other research issues* (Vol 4 of 6) (AL-TP-1991-0017-Vol-4). Brooks AFB, TX: Armstrong Laboratory, Human Resources Directorate.

Gagné, R. M. (1985). *The conditions of learning* (4th ed.). New York: Holt, Rinehart, and Winston.

Gagné, R. M. (1992). *Tryout of an organizing strategy for lesson design: Maintenance procedure with checklist* (AL-TP-1992-0016). Brooks AFB, TX: Armstrong Laboratory, Human Resources Directorate.

Gagné, R. M. & Merrill, M. D. (1990). Integrative goals for instructional design. *Educational Technology Research and Development*, 38(1), 23-30.

Gagné, R. M., Tennyson, R. D., & Gettman, D. J. (1991). *Designing an advanced instructional design advisor: Conceptual frameworks* (Vol 5 of 6) (AL-TP-1991-0017-Vol-5). Brooks AFB, TX: Armstrong Laboratory, Human Resources Directorate.

Golas, K. C. & Shriver, S. (1991). *Revision of the Air Force instructional systems development process: Baseline analysis report* (Contract No. F42650-87-D-0026). Randolph AFB, TX: Air Training Command/XPCR.

Merrill, M. D. Li, Z., & Jones, M. K. (1990). Second generation instructional design (ID-2).

Educational Technology 30(2).

Muraida, D. J. & Spector, J. M. (1990). The advanced instructional design advisor (AIDA): An Air Force project to improve instructional design. *Educational Technology*, 30(3), 66-67.

Rich, E. & Knight, K. K (1991). *Artificial intelligence* (2nd ed.). New York: McGraw Hill.

Rowland, G. (1992). What do instructional designers actually do? An initial investigation of expert practice. *Performance Improvement Quarterly*, 5(2), 65-86.

Spector, J. M. (1990). *Designing and developing an advanced instructional design advisor* (AFHRL-TP-90-52). Brooks AFB, TX: Human Resources Laboratory, Technical Training Division.

Spector, J. M., Muraida, D. J., & Dallman, B. E. (1990). Establishing instructional strategies for advanced interactive technologies. *Proceedings of the Psychology in the DoD Symposium* (USAFA-TR-90-1). USAFA, CO: USAF Academy, Department of Behavioral Sciences and Leadership.

Spector, J. M. & Muraida, D. J. (1991, March). *When CBT speaks: Guidelines for incorporating Audio.* Paper presented at the annual CBT Conference and Exposition, Orlando, FL.

Spector, J. M., Gagné, R. M., Muraida, D. J., & Dimitroff, W. A. (1992, April). *Intelligent frameworks for instructional design.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Stephenson, S. D. (1992). *The effects of student-instructor interaction on achievement in a dyad computer-based training environment* (AL-TP-1992-0005). Brooks AFB, TX: Armstrong Laboratory, Human Resources Directorate.

Tennyson, R. D. (1991) Framework Specifications for an Instructional Systems Development Expert System. In Gagné, R.M., Tennyson, R.D., & Gettman, D.J. *Designing an advanced instructional design advisor: Conceptual frameworks.* (Vol 5 of 6) (AL-TP-1991-0017-Vol-5). Brooks AFB, TX: Armstrong Laboratory, Human Resources Directorate.